Coupling of Precipitation and Cloud Organization to Moisture Transport in Extratropical Cyclones

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Objectives

- Use extratropical cyclones (ETCs) to link precipitation and cloud organization to moisture transport.
- Identify the associated feedback to ETC development

$$P - E + \frac{\partial Q}{\partial t} = -Q\nabla\cdot\vec{V} - \vec{V}\cdot\nabla Q$$

where

$$Q = \int_{ptop}^{psrf} q\frac{dp}{g}$$

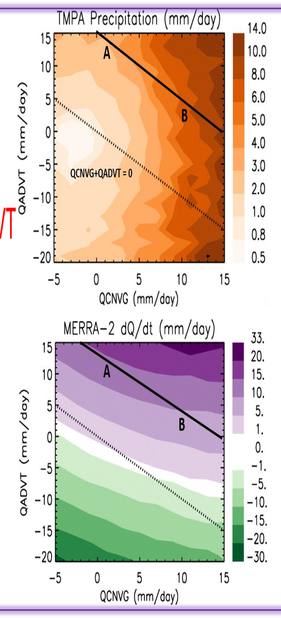
$$\vec{V} = \frac{1}{Q}\int_{ptop}^{psrf} (q\vec{v})\frac{dp}{g}$$

QCNVG

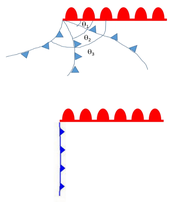
QADVT

P: Precipitation

E: Evaporation



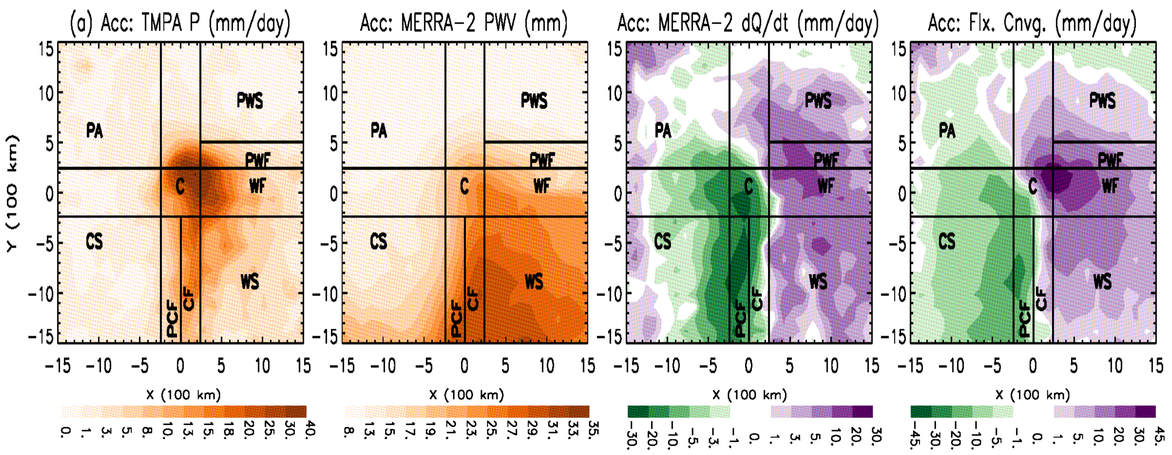
A: Water vapor convergence is used to moisten (∂Q/∂t >> P) the atmosphere rather than to form rain.
B: Precipitation formation is favored (P >> ∂Q/∂t).
Inference: A and **B** have the same moisture convergence but different clouds.



ETC Coordinate System

Look at ETCs in a coordinate system in which the warm fronts are along positive-x, and the cold fronts along negative-y directions.

Precipitation, Precipitable Water, and Moisture Budgets in ETC Coordinates



- Cold front (CF) and warm sector (WS): Strong precipitation occurs in regions of maximum precipitable water.
- Pre-warm front (PWF) and warm front (WF): A large portion of water vapor convergence is used to moisten the atmosphere: precipitation does not occur where precipitable water is maximum.
- Although WF and CF have similar precipitation amount, their cloud type combinations differ.

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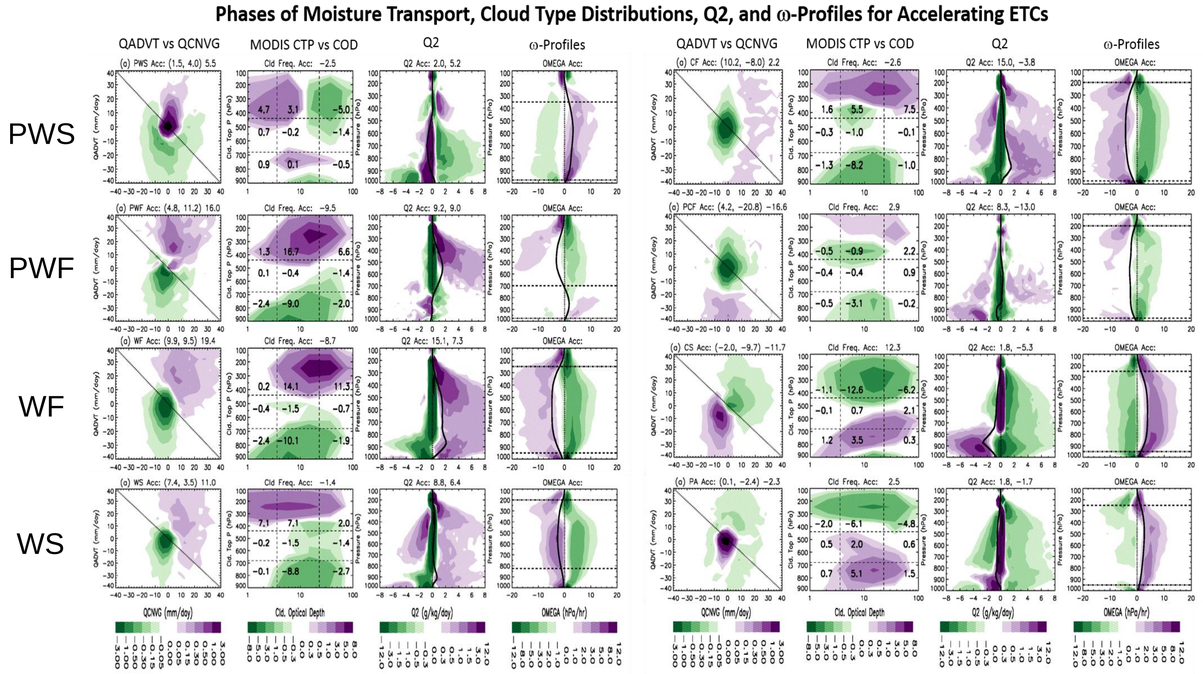
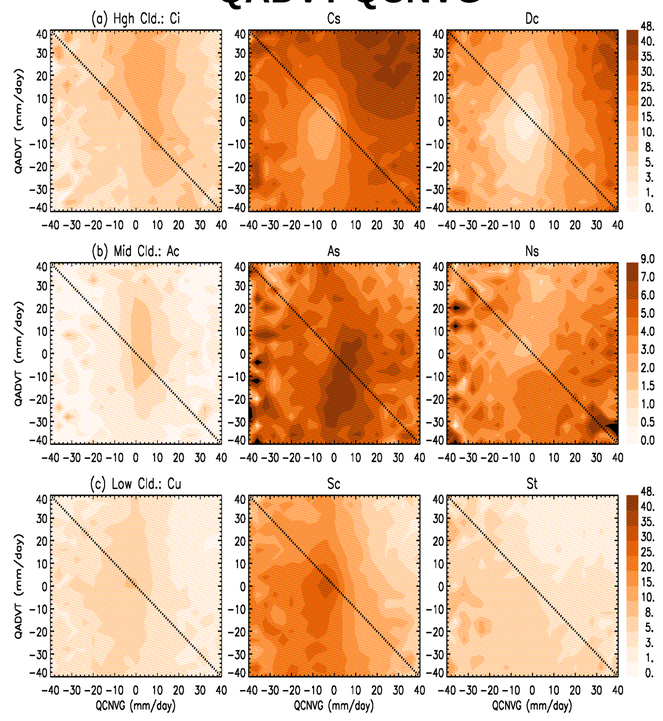
Phases of Moisture Transport, Cloud Type Distributions, Q2, and ω-Profiles for Accelerating ETCs



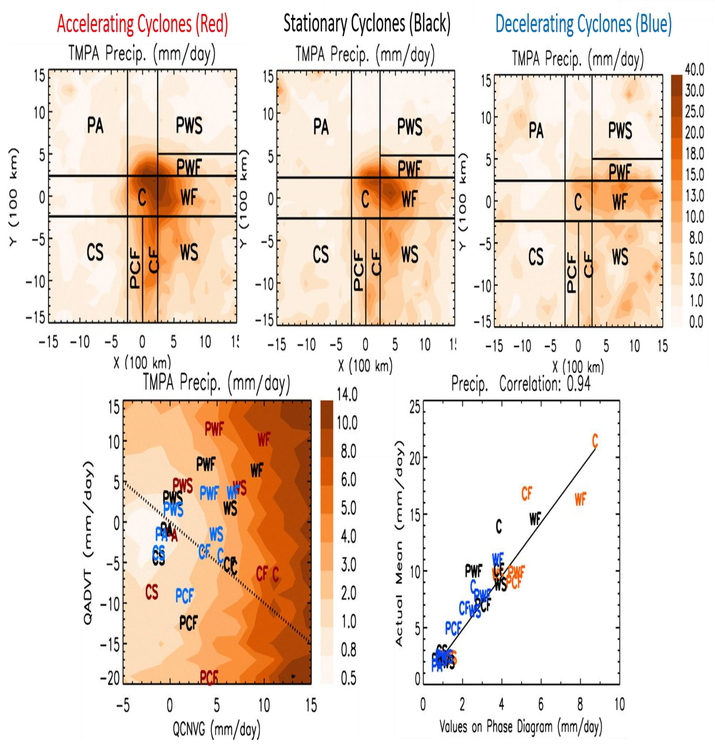
Moisture Transport and Cloud Organization

- Pre-warm sector (PWS) and PWF: Moisture transport is advective (QADVT >> QCNVG). The atmosphere is moistened with frequent occurrence of high, moderately thick clouds (or Cs).
- WF and CF: Similar QCNVG implies similar precipitation amount. More negative QADVT in CF leads to its less Cs compared to Dc.

Cloud Type Frequency Distributions in QADVT-QCNVG



Precipitation Variability and Phases of Moisture Transport



Conclusions

- Phases of moisture transport (QADVT vs QCNVG) control precipitation variability and cloud organization in ETCs
- Deepening ETCs have rapid moisture supply and ventilation by the atmosphere, while decaying ETCs correspond to slower moisture transport processes.
- Deepening ETCs are more efficient in meridional transport of water vapor.